MANITOBA SCIENCE ASSESSMENT 1986

SUMMARY REPORT

ENGLISH LANGUAGE AND
FRENCH IMMERSION PROGRAMS

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ENGLISH LANGUAGE AND FRENCH IMMERSION PROGRAMS

A REPORT OF THE
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PREFACE

This Summary Report is the third of three reports of the findings of the 1986 Science Assessment. It contains a brief description of the study along with recommendations based not only upon teacher and principal opinions but also upon the judgment of the Technical Advisory Committee. Members of the Committee reviewed the data and interpreted them in the light of their considerable knowledge and experience. Teachers and school administrators are encouraged to review the recommendations for applicability to their own programs.

There are two other reports on this assessment. They are the Preliminary Report which presents the actual data and the Final Report which analyzes the data and presents conclusions and recommendations.

The Preliminary Report was distributed to all schools in the province as well as to school division offices, to teacher and trustee organizations, to libraries, and to the universities. This Summary Report will receive the same distribution as the Preliminary Report, while the more extensive Final Report will only be distributed to school division offices, teacher and trustee organizations, libraries, and universities. Copies of the Final Report, however, can be obtained from Manitoba Education on request.

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- The Science Technical Advisory Committee which advised on test production and analysis of results;
- The Science Interpretation Panels;
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- The school administrators, teachers, and students who were involved in the pilot testing;
- The teachers who participated in the teacher surveys;
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- Drs. L. Graham, D. Anderson, and R. Connor of the Faculty of Science, University of Manitoba.
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SCIENCE SUMMARY REPORT

The 1986 Science Assessment is the second science assessment conducted in Manitoba. The first assessment took place in November, 1980, and provided an indication of the science performance of public school students in Manitoba. This science assessment took place in May, 1986, at grade levels 3, 6, and 9. The purposes of the 1986 Science Assessment were similar to those of the 1980 assessment, and are:

1. to provide benchmark indicators relative to the level of science achievement in Manitoba,

2. to obtain data on student science achievement which will assist in curriculum and program improvement at various levels,

3. to assist school divisions with student evaluations in science,

4. to help teachers improve their skills in evaluating students in science.

The tests were developed to survey student performance on the knowledge, understanding, skills, and attitudes that constitute the Manitoba Science curriculum. The student testing included two components: a written component which consisted of both cognitive and affective questions, and a performance component which required students to use their science skills, to apply knowledge of science concepts, and to use common laboratory equipment.

Two other components were incorporated in the 1986 Science Assessment Program: a survey of science teachers in grades 1 to 6, and a comparison test which was given in November, 1985, using items selected from the 1980 assessment.

PROCEDURES

Goals and objectives from the science curriculum guides for kindergarten to grade 9 were reviewed by the Science Technical Advisory Committee (TAC) and by science teachers from most school divisions at regional meetings. After this review process, the TAC decided on the content to be covered in the written, performance and comparison tests. The tests were developed by science education specialists who were given a contract by the Department for the Science

Assessment. These tests were then reviewed by the TAC, revised, piloted, and revised again in light of the pilot. The test instruments in the written and performance components were developed for the three grade levels in both English and French.

Approximately ten percent of all students enrolled in English and French Immersion programs at grades 3, 6, and 9 in Manitoba's public schools constituted the provincial sample. The results of testing this sample of students are discussed in this report. A separate sample of students enrolled in Français programs was also tested. Results of this testing appear in separate reports. In both cases the written tests were administered by the classroom teachers whereas the performance tests were supervised by trained testers. Because of the relatively small samples employed for the performance testing, results for the English, French Immersion, and Français populations were combined for purposes of analysis and reporting.

The Preliminary Report, a detailed presentation of the student data from the written component of the assessment, was mailed to schools in October, 1986.

INTERPRETATION OF RESULTS

All assessment results were accumulated in percentages and were judged as to their quality and adequacy by Interpretation Panels, working in groups at each grade level. These panels estimated two levels of performance, "adequate" and "desirable", for each test item (except attitude items). Each grade group then made interpretation ratings regarding the obtained student results. The median interpretation ratings for items and for goals, and the recommendations resulting from these ratings have been considered in writing this report. Interpretation Panel ratings were not made for the performance component. For this component, the students' results were reported as to their success for each test item.

NATURE OF THE ASSESSMENT

The written and performance student tests were designed to assess scientific knowledge, understanding, and skills, and to report the perceived attitudes of the students. The major categories and subcategories of the assessment framework together with the number of items at each grade level are indicated in Table 1.

Table 1

Categories of Science Assessed by the Written Component Tests

Categories	Number of Items		
	Grade 3	Grade 6	Grade 9
A. CONTENT OF SCIENCE			
1. Facts	10	13	14
2. Terminology	8	9	11
3. Concepts/Relationships	6	10	9
4. Theories and Conceptual Schemes	1	5	4
5. Explanation of Physical Phenomena	5	3	2
6. Trends and Sequences	2	3	3
B. PROCESSES			
7. Observing and Classifying	9	5	
8. Measuring/Quantifying	7	4	
9. Identifying, Collecting, Interpreting, Reporting Data	8	11	25(combined
10. Making Inferences/Hypothesizing	5	10	
11. Building, Testing, and Revising Theoretical Models	no items	4	for all processes)
C. SKILLS FOR SCIENCE			
12. Skills Using Laboratory Equipment	no items	no items	14
13. Skills Associated with Safety	no items	no items	7
D. PROBLEM-SOLVING AND DECISION-MAKING			
14. Cognition	2	3	4
15. Following Instructions/Using Algorithms	no items	no items	5
16. Using Inquiry Techniques	no items	7	4
17. Application of Knowledge	3	3	2
E. ATTITUDE TOWARD SCIENCE			
18. Enjoying Science	5	5	3
19. Valuing Science	4	8	4
20. Adopting Attitudes of Science	3	3	9
21. Making Career Decisions	2	7	16
F. SCIENCE AND SOCIETY			
22. Science in Canada	no items	no items	10
23. Health, Nutrition and Agriculture	3	4	5
24. Environment	3	4	2
25. Energy	1	2	3
26. Recreation	no items	no items	no items
G. NATURE OF SCIENCE			
27. History of Science	no items	8	10
28. Philosophy of Science	no items	no items	1
Total:	87	131	167

OVERVIEW OF RESULTS

The written, performance and comparison components of the 1986 Science Assessment will be considered individually in this Summary Report. The purpose of this overview is to present a reasonably concise answer to the question: "How well did Manitoba students do?"

By the time Manitoba public school students have finished their **grade 3** education they should have acquired a satisfactory knowledge of the content and processes of science consistent with their grade level. However, the assessment results reveal that grade 3 students often had difficulty providing complete and precise written responses and that the concept of providing more than one answer to a single question was generally not an experience with which they were familiar. With respect to the processes of science, these students did well but had a fair degree of difficulty with items involving measurement. The performance component indicates that these children were enthusiastic about science but were not yet familiar with many aspects of the inquiry approach.

Students who have completed the **grade 6** science curriculum in Manitoba schools were doing acceptably well in the categories which require fairly conventional lower-level thinking skills and emphases but were not doing well in application, synthesis and analysis and in areas of more recent emphasis such as Applications of Science to Society and the Nature of Science. In the affective domain these students seemed to favour science generally but had difficulty in identifying the values of science. Grade 6 pupils had difficulty with written responses and explanations. These students experienced the greatest difficulty in the conceptual areas involving the Physical Sciences and the Earth Sciences. They were enthusiastic about laboratory investigations but showed evidence of much weakness in their ability to use inquiry techniques.

The comparison between grade 8 students in 1980 and 1985 shows that students did less well in 1985. This almost certainly affected the grade 9 students' written and performance results in the 1986 assessment. **Grade 9** students believed that science is an important subject but this positive attitude did not translate into satisfactory achievement. While this large assessment component had its bright spots, overall it was poorly done. The written and performance results indicate that grade 9 students did most poorly on the basic experimentation processes of observing, hypothesizing, identifying the cause and effect variables and in controlling variables. Concepts from the Physical and Earth Sciences seemed to present the greatest difficulty for students at this grade level. Written responses were more of a problem than objective items.

THE WRITTEN COMPONENT

Grade 3 pupils in Manitoba have a chronological age from 7-9 years. Their language arts skills are just developing and they are generally eager to express themselves. The Science Assessment written component asked these youngsters to respond to 87 items which were grouped into five distinct categories. The first three categories: Content of Science (32 items), Processes of Science (29 items), and Problem-Solving and Decision-Making (five items) contain questions that require cognitive responses. The categories Attitude toward Science (14 items), and Science and Society (seven items) contain questions that require affective responses. Although an effort was made to simplify the vocabulary, the results indicate that grade 3 pupils had difficulty understanding the intent of some questions in the affective categories.

Table 2 summarizes grade 3 students' performance on the cognitive items in the written test.

Table 2
Grade 3 Performance on Cognitive Subtests

	Subtest	Questions Per Subtest	Mean Raw Score	Mean Percent
A.	CONTENT OF SCIENCE			
	A1. Facts	10	7.16	71.59
	A2. Terminology	8	4.92	61.53
	A3. Concepts/Relationships	6	4.12	68.69
	A4. Theories and Conceptual Schemes	1	0.63	62.72
	A5. Explanation of Physical Phenomena	5	1.90	38.02
	A6. Trends and Sequences	2	0.94	46.83
	(TOTAL)	32	19.67	61.46
B.	PROCESSES			
	B7. Observing and Classifying	9	6.88	76.42
	B8. Measuring/Quantifying	7	4.60	65.67
	B9. Identifying, Collecting, Interpreting, Reporting Data	8	6.14	76.74
	B10. Making Inferences/Hypothesizing	5	3.59	71.86
	(TOTAL)	29	21.21	73.13
D.	PROBLEM-SOLVING AND DECISION-MAKING			
	D14. Cognition	2	0.95	47.25
	D17. Application of Knowledge	3	1.11	36.99
	(TOTAL)	5	2.05	41.10
TOTAL TEST (COGNITIVE)		66	42.93	65.04

The results of the written component indicate that grade 3 pupils had a good understanding of the content and processes which are identified in the provincial

curriculum guide for this grade level. They appeared to have a somewhat lesser understanding in the area of problem-solving (41% mean score). Here pupils were asked to identify a problem or to apply scientific knowledge to suggest a possible solution to a problem. Grade 3 students experienced the most difficulty with items which are associated with measurement. They were able to compare lengths and temperatures and to identify the best device to measure the length of an object but 68% were not able to estimate the amount of liquid in a measuring cup using interpolation, and 59% were not able to estimate the height of a hill using a tree as a unit of measurement, given a picture of the hill and a tree at the base of the hill. Coincidently these same students did very well (77% mean score) when asked to read and interpret information presented in charts, tables, and graphs.

The cognitively-related items were also organized and analysed according to the content themes of the curriculum. Students did best on the Earth/Space/Time theme (67% mean score), followed by the Interdependency and Interaction Among Organisms theme (64% mean score) and the Changes in Matter and Energy theme (59% mean score).

Grade 3 pupils' attitude towards aspects of science were assessed by items which asked them to identify beliefs, attitudes, values, enjoyment, and preferences which were most in agreement with their feelings. The results indicate that grade 3 students overall had a very positive attitude toward science. These same students however, indicated that they were not highly interested in science programs on television or that they were likely to read science magazines. The majority of these students believed that science can help control weather, stop pollution, and cure sick people. Fewer students believed that science can help prevent wars.

Grade 6 written test results are presented in much greater detail in chapter 4 of the 1986 Science Assessment Final Report. The grade 6 written assessment test consists of 131 items covering seven major areas of science in both the cognitive and affective domains. Overall, the results can probably be best expressed as "marginal" with the best results occurring in the areas which require lower-level thinking skills.

Table 3 on the next page summarizes grade 6 students' performance on the cognitive items in the written test.

Table 3
Grade 6 Performance on Cognitive Subtests

	Subtest	Questions Per Subtest	Mean Raw Score	Mean Percent
A.	CONTENT OF SCIENCE			
	A1. Facts	13	8.02	61.67
	A2. Terminology	9	4.43	49.24
	A3. Concepts/Relationships	10	6.80	68.02
	A4. Theories and Conceptual Schemes	5	1.73	34.59
	A5. Explanation of Physical Phenomena	3	1.57	52.23
	A6. Trends and Sequences	3	1.43	47.79
	(TOTAL)	43	23.98	55.77
B.	PROCESSES			
	B7. Observing and Classifying	5	3.52	70.44
	B8. Measuring/Quantifying	4	2.47	61.73
	B9. Identifying, Collecting, Interpreting, Reporting Data	11	6.27	56.96
	B10. Making Inferences/Hypothesizing	10	6.84	68.44
	B11. Building, Testing, and Revising Theoretical Models	4	1.80	44.94
	(TOTAL)	34	20.90	61.46
D.	PROBLEM-SOLVING AND DECISION-MAKING			
	D14. Cognition	3	1.73	57.59
	D16. Using Inquiry Techniques	7	3.63	51.92
	D17. Application of Knowledge	3	0.90	30.03
	(TOTAL)	13	6.26	48.18
E.	ATTITUDE TOWARD SCIENCE			
	E21. Making Career Decisions	5	4.13	82.51
	(TOTAL)	5	4.13	82.51
F.	SCIENCE AND SOCIETY			
	F23. Health, Nutrition and Agriculture	4	2.26	56.58
	F24. Environment	4	1.66	41.50
	F25. Energy	2	0.69	34.59
	(TOTAL)	10	4.62	46.15
G.	NATURE OF SCIENCE			
	G27. History of Science	8	4.50	56.20
	(TOTAL)	8	4.50	56.20
TOTAL TEST (COGNITIVE)		113	64.38	56.97

In the cognitive domain, grade 6 students performed satisfactorily or better in eight of 18 categories, they were marginal in eight categories and unsatisfactory in three categories. The unsatisfactory categories were Theories (35% mean score), Application of Knowledge (30% mean score) and Energy (35% mean score). Overall achievement for the six categories comprising Content of Science was 56%, for the five categories comprising Processes of Science 61% and for the three categories comprising Problem-solving and Decision-making 48%. For the three categories comprising Science and Society these students received a mean achievement score of 46% and for the one category under History of Science 56%.

Although these students indicated a positive attitude toward the value of science they had difficulty with many questions dealing with the investigative nature of science, e.g., collecting, interpreting and reporting data. They had a reasonable knowledge of facts and the elementary processes of science. They had a

degree of skill in using inquiry techniques in problem-solving areas that are independent of application of knowledge and its associated decision-making.

When the cognitive items are grouped and analysed according to the content themes of the Manitoba K-6 curriculum, students performed best on the Interdependency and Interaction Among Organisms theme (63% mean score), then followed by the Changes in Matter and Energy theme (50% mean score) and worst on the Earth/Space/Time theme (49% mean score).

The assessment results indicate that Manitoba grade 6 students had greatest difficulty in the areas of Physical Science and Earth Science and with Problem-solving and Decision-making generally. The results also indicate that these students had the most difficulty with questions calling for written responses and explanations.

Grade 9 written test results are expressed in more detail in chapter 6 of the 1986 Science Assessment Final Report. For grade 9, the results are reported in accordance with seven major testing areas. While there are certainly some satisfactory areas the overall results are generally considered to be low.

Table 4 summarizes grade 9 students' performance on the cognitive items in the written test.

Table 4
Grade 9 Performance on Cognitive Subtests

Subtest	Questions Per Subtest	Mean Raw Score	Mean Percent
A. CONTENT OF SCIENCE			
A1. Facts	14	5.67	40.47
A2. Terminology	11	3.74	34.00
A3. Concepts/Relationships	9	4.75	52.74
A4. Theories and Conceptual Schemes	4	0.54	13.48
A5. Explanation of Physical Phenomena	2	0.55	27.48
A6. Trends and Sequences	2	0.52	25.83
(TOTAL)	42	15.76	37.52
B. PROCESSES (TOTAL)	25	10.19	42.45
C. SKILLS FOR SCIENCE			
C12. Skills Using Laboratory Equipment	14	5.75	41.08
C13. Skills Associated with Safety	7	4.07	58.09
(TOTAL)	21	9.82	46.75
D. PROBLEM-SOLVING AND DECISION-MAKING			
D14. Cognition	4	2.40	59.95
D15. Following Instructions/Using Algorithms	5	1.79	35.77
D16. Using Inquiry Techniques	4	1.92	48.01
D17. Application of Knowledge	2	0.77	38.40
(TOTAL)	15	6.87	45.83
F. SCIENCE AND SOCIETY			
F23. Health, Nutrition and Agriculture	5	2.16	43.22
F24. Environment	2	0.79	39.29
F25. Energy	3	0.91	30.31
(TOTAL)	10	3.86	38.56
G. NATURE OF SCIENCE			
G27. History of Science	10	5.32	53.23
(TOTAL)	10	5.32	53.23
TOTAL TEST (COGNITIVE)	122	51.82	42.47

Content of Science comprises the largest of the subtest areas (42 test items). In this area grade 9 students performed best in the category of Concepts (nine items - 53% mean score), and least well in the area of Theories (four items - 13.0%). The overall mean score for Content of Science was 37.5%.

The integrated Processes of Science are a second major area of the written assessment (25 test items). This area utilizes items that were designed especially for testing the scientific process as opposed to content knowledge. The results indicate that grade 9 students were able to handle data tables and illustrations but they did poorly with respect to basic inquiry investigation when the processes of observing, hypothesizing, and identifying and controlling variables were integrated into the experimental mode. The mean score for this area was 42%.

For the subtest which measures Science Safety Skills and Laboratory Skills (21 items) students achieved a 58% mean score for the Safety Skills and 41% for the Laboratory Skills.

In the area of Problem-solving and Decision-making, grade 9 students did well on the four items comprising Cognition (60%) but did less well on Following Instructions and Using Laboratory Techniques. The total mean score for this subtest was 46%.

For the affective portion of the written assessment grade 9 students indicated that 42% of this group enjoyed science "very much" or "quite a bit", while 24% said "not at all" or "very little". These students generally believed that science is an important subject (79%) and that it is a moderately difficult subject to study (58%).

The degree to which grade 9 students were adopting a scientific attitude is favourable. Most of these students were not overly superstitious and they believed science plays an important part in today's society.

In the Science and Society subtest the assessment results reveal that Manitoba students were not familiar with Canada's contributions to science and they knew little of the relationship between science and agriculture. In the subtest on Nature of Science these students indicated that they were aware of many historical aspects of science but had little perception of the philosophy of science.

THE PERFORMANCE COMPONENT

Please Note: A great deal of data was collected on the component and it is difficult to summarize the material accurately . Readers should refer to the Final Report for details.

Performance testing was used to assess how well students were doing in attaining curriculum objectives that were difficult to measure or are not adequately measured by the written test format. The TAC determined which objectives would be measured by this method. The categories of objectives measured were: using common laboratory equipment; safety; following instructions; explaining physical phenomena; observing and classifying; measuring and quantifying; identifying, collecting, interpreting, and reporting data; making inferences and hypothesizing; cognition; and using inquiry techniques.

The performance methods used at each grade level varied as did the categories which were involved. At all levels two basic approaches were used: the Station and the Individual. The Station Approach consisted of a circuit of stations with one student working at each for a prescribed period of time, whereas the Individual Approach tested one student for an extended time. A written set of instructions and a set of materials was provided. A testing supervisor observed the student at work and collected required data as the student proceeded. The results are summarized for each type of task and grade level.

GRADE 3 RESULTS

Station Tasks

Six station tasks were used: BLOCKS OF WOOD, OBJECTS, BIRDS, MARBLES IN TUBES, BOATS, and SEEDS. The BLOCKS OF WOOD task required students to weigh two blocks of wood and estimate the weight of a third block. The OBJECTS task required students to classify objects correctly into groups. The BIRDS task required students to observe and record differences in pictures of two different birds. The MARBLES IN TUBES task required students to observe and describe differences in behaviour of marbles in three different tubes of liquid as the tubes are turned upside down. The BOATS task required students to float three boats in fresh water and predict the behaviour of the third boat in salt water on the basis of how the other two boats float in salt water. The SEEDS task required

students to divide bags of seeds into two groups. The following generalizations can be made from the results:

1. Most students were successful in their observation and classification skills and many were able to give correct reasons for their statements.

2. About two-thirds were able to measure the mass of wood blocks using a pan balance; however, very few were able to estimate the mass of a third wood block.

3. Most students were able to record their first observations, but fewer recorded any second and third observations.

4. For interpretation of data, the success rate of the students seemed to depend on the context of the situation. For the Bird task, many were successful, whereas for the Marbles in Tubes, and the Boats, fewer were correct.

5. The students were least successful with questions dealing with inferring and predicting.

Individual Tasks

Four individual tasks were used: BOUNCING BALLS, COLOURED LIQUIDS, SUGAR LUMPS, and MEAL WORMS. The BOUNCING BALL task required students to determine from which of three surfaces a ball bounced best. The COLOURED LIQUIDS task required students to measure the temperature of a liquid and observe the effects of adding drops of unknown liquids. The SUGAR LUMPS task required students to determine whether sugar lumps or ordinary loose sugar dissolved more quickly. The MEAL WORMS task required students to determine which of several foods were preferred by meal worms. The results for the different objectives varied according to the context of the tasks, but some generalizations can be made:

1. For the three categories which were assessed by this format only, the following results are evident:
   a) laboratory equipment was used properly except the hand lens,
   b) safety procedures were carefully observed, and
   c) about half the students followed the instructions carefully.

2. The students' explanations of physical phenomena varied from very successful to totally incorrect depending on the situation.

3. Observing was very well done.

4. The measurement skills varied with the task. Few dropped the ball from a measured height or measured the bounce, most were able to measure the volume of the water but not the temperature. For the Sugar Lumps task, almost none measured the time of dissolving, but

about half measured equal amounts of sugar and water. For the meal worms over half measured equal amounts of foods, and placed the worms at equal distances from the foods, but none timed the eating periods.

5. Most children were successful in recording and interpreting their results in all situations.

6. Their skill in predicting was very good.

7. Most students seemed to understand the inquiry problem.

8. The weakest category was in the use of inquiry techniques. Very few controlled variables or repeated the task unless instructed to do so. They did best with the Meal Worm task in placing equal amounts of food at equal distances from the meal worms.

GRADE 6 RESULTS

Station Tasks

Six station tasks were presented: CIRCUITS, ROCKS AND MINERALS, BIRDS, WATER, BOATS, and DIVERS. The CIRCUITS task required students to assemble and test a circuit and test different materials for conductivity. The ROCKS AND MINERALS task required students to test different minerals for hardness and place them in order of hardness. The BIRDS task was essentially the same as the one used in grade 3. The WATER task required students to take the temperature of two glasses of water and measure the temperature when they are mixed. They were then given hypothetical data and asked to predict the effects of mixing two liquids. The BOATS task was essentially the same as the one given to grade 3 students. The DIVERS task asked students to observe and explain the behaviour of different "divers" as a bottle containing them was squeezed. The following generalizations can be made from the results:

1. For the two stations (Birds and Boats) which were the same as the grade 3s, the results were considerably better in all of the processes tested for: observing, recording data, interpreting data, and predicting.

2. The students were very successful in their observation skills, particularly in explaining differences. However, for the Divers station they did not record all observations.

3. Over half the students were able to measure the temperature of water accurately.

4. For interpretation of data the students did very well with the Circuits and Birds stations, but were much less successful with the Boats, and Rocks and Minerals tasks.

5. Less than one quarter of the students were successful at predicting and inferring.

Individual Tasks

Four individual tasks were presented. These were the same tasks as those given to the Grade 3s. The results indicate that:

1. The grade 6 students were more proficient or as good as the grade 3 children. They did much better in measuring, predicting, using laboratory equipment, and in inquiry techniques. Following instructions improved the most.

2. For the three categories which were assessed exclusively by this format, the results are as follows:
   a) laboratory equipment was used properly by most of the students,
   b) safety procedures were carefully observed, and
   c) most of the children followed instructions carefully.

3. Explanations of physical phenomena were well done except for the Sugar Lumps task.

4. Observing was very well done.

5. Measurement skills were well done except in timing aspects and in measuring the height and bounce of the ball.

6. Most children were successful in recording and interpreting their results in all situations.

7. Their skills in prediction were excellent.

8. Nearly all students seemed to understand the inquiry problems.

9. The weakest category was in the use of inquiry problems. The grade 6 students were only slightly better than the grade 3 students.

GRADE 9 RESULTS

Station Tasks

Four station tasks were used: MICROSCOPES, SIMPLE MACHINES, MEASUREMENT, and EARTH SCIENCE. The MICROSCOPE task consisted of a series of questions and exercises based on the use of the microscope. The SIMPLE MACHINES task consisted of a series of questions and exercises based on simple lever and pulley systems. The

MEASUREMENT task required students to perform measurements of length, volume, temperature and mass and to perform a density calculation. The EARTH SCIENCE task consisted of a series of questions dealing with rock hardness, soil particle size, and water retention properties of soil. The following generalizations can be made from the results:

Microscope

1. Half of the students were able to identify the important parts of a microscope.

2. Three-quarters of the students were able to focus the microscope, draw an object on a slide, and identify an opaque object as the most difficult to view through a microscope.

3. One-quarter of the students were able to identify a specific part of a cell under a microscope.

Simple Machines

1. Few students were able to assemble a first-class lever and then measure the force needed to lift an object.

2. Almost no students were able to determine the theoretical or actual mechanical advantage of a first-class lever. Few students expressed a general knowledge of the factors associated with mechanical advantage.

3. Half of the students were able to measure the force needed to lift a mass on a two-pulley system. Very few of the students were able to state the theoretical or mechanical advantage of this system.

4. Half of the students were able to measure the force needed to lift a mass with a four-pulley system. Only 14% were able to determine the ideal mechanical advantage of this system. Almost none were able to calculate the work done in this system.

Measurement

1. Two-thirds were able to measure a linear distance accurately, and one-quarter were able to measure the volume of a liquid accurately to the nearest ml.

2. Between one-half and three-quarters of the students were able to measure the temperature of cool and warm liquids to the expected degree of accuracy.

3. Nearly three-quarters were able to measure the mass of a solid substance.

4. Less than one-fifth of the students were able to determine the volume of a cylinder using water displacement, but two-thirds were able to determine the mass. Almost none were able to determine the density of this cylinder.

Earth Science

1. Over half were unable to use a hardness scale to determine the hardness of minerals.

2. In determining particle size, over one-half of the students identified the relative particle sizes of specimens provided.

3. Three-quarters of the students were able to follow directions and report the volume of water poured through the three soils. Fewer were able to report the volume of the water remaining in the soils.

4. Over half were able to infer the relationship between particle size and water retention.

Individual Tasks

Four individual tasks were used: SUGAR LUMPS, MEAL WORMS, BOUNCING BALLS, and FLYING STRAW AIRPLANES. The first three tasks were modified versions of those given to grades 3 and 6 students; the fourth task, Flying Straw Airplanes, was designed specifically for grade 9 students. In this task, students were to try several different designs of airplanes to determine which flew better. The results are:

Sugar Lumps

1. In this investigation involving the solubility rate, about two-thirds of the students were able to develop a procedure and obtain satisfactory results, but less than one-half were able to infer two or more factors which influence solubility.

2. About half controlled the temperature and volume of the solvent, and mass of the solute. One-quarter controlled two of these variables.

Meal Worms

1. In this investigation students were asked to determine if meal worms prefer one kind of food over another. Over one-half were able to state a final preference.

2. Two-thirds did some planning before doing the experiment.

3. The variables which were controlled varied widely: amount of food (one-tenth of the students), opportunity to eat (over one-third), time (less than 10%). Most students used at least three foods and more than one worm.

Bouncing Balls

1. In this task students had to determine the best bouncing ball (of three) on three surfaces. About three-quarters of the students reported their results with respect to at least one surface.

2. Over three-quarters of the students seemed to be considering all three balls and all three surfaces. One half had a consistent release pattern and less than half measured the height of both release and bounce. About one-third replicated their trials.

3. Most students did not seem to understand the 3 x 3 data collection requirements. Three-quarters mentioned at least one surface when they were asked to explain why they picked a ball as a best bouncer.

Flying Straw Airplanes

1. In this task where students have the opportunity to develop the best design for a paper airplane, three different designs were created by just over half of the students.

2. Few showed evidence of understanding the scientific procedures involved. Less than one-fifth indicated both dependent and independent variables. Less than one-quarter replicated flight trials. Few students measured the flight distance.

SCIENCE COMPARISON TESTING, 1980-85

The 1986 Manitoba Education Science Assessment Program included a comparison testing component. The objective of this component was to determine whether any change had occurred in student achievement in science from the time of the 1980 Science Assessment (November, 1980) to the time of the comparison testing (November, 1985). Representative items that still retained curricular relevance were selected from the 1980 written tests and given to a sample of grade 5, 8, and 11 students.

Some significant and noteworthy differences were evident at certain grade levels. The **grade 5** results show little change in achievement. There was a slight positive change in the area of Earth Science and Weather but in the Nature of Science area there was a slight negative change. The highest score was in the category Processes of Science, the lowest in Earth Science and Weather. Basically, the grade 5 scores indicate "little or no change" with achievement levels of between 42% and 64%. The grade 5 results are presented below in Table 5:

Table 5
Grade 5 Comparison Results

Topic	No. of Items	1980 Mean Raw Score	1980 Mean %	1985 Mean Raw Score	1985 Mean %	
Nature of Science	3	1.721	57%	1.669	56%	*
Processes of Science	6	3.926	65%	3.866	64%	
Astronomy	3	1.805	60%	1.839	61%	
Earth Science & Weather	6	2.472	41%	2.544	42%	*
Physical Science	9	3.898	43%	3.926	44%	
Life Science	8	3.973	50%	4.007	50%	
TOTAL	35	17.80	51%	17.85	51%	

* indicates statistical significance (p=.05)

Grade 8 students scored less well on all topics in the 1985 comparison test with achievement levels ranging from 47% to 54%. The average negative changes were 3% except for a 7% drop in the Nature of Science. Grade 8 achievement was highest in Nature of Science, and lowest in Weather. The grade 8 results are presented below in Table 6:

Table 6
Grade 8 Comparison Results

Topic	No. of Items	1980 Mean Raw Score	1980 Mean %	1985 Mean Raw Score	1985 Mean	
Weather	11	5.657	51%	5.221	47%	*
Physical Science	13	6.642	51%	6.188	48%	*
Life Science	10	5.065	51%	4.791	48%	*
Process of Science	12	6.584	55%	6.206	52%	*
Safety in Science	4	2.084	52%	1.945	49%	*
Nature of Science	3	1.823	61%	1.634	54%	*
TOTAL	53	27.85	53%	25.99	49%	

* indicates statistical significance (p=.05)

The **grade 11** comparison test-subject areas were broken down into fifteen topics in all. The students performed better on three topics: Earth Science, Physical Properties of Matter, and Safety in Science. They stayed virtually the same on six topics: Force, Work and Energy; Structure of Matter, Chemical Properties of Matter, Life Science, Nature of Science, and Laboratory Techniques. They performed less well on six topics: Weather, Astronomy, Electricity and Magnetism, Heat and Temperature, Light, and Processes of Science. The scores on Weather, Heat and Temperature, and Light were lower by more than 5 or more percent. Achievement levels ranged from 41% (Weather) to 72% (Nature of Science). The grade 11 results are presented below in Table 7:

Table 7
Grade 11 Comparison Results

Topic	No. of Items	1980 Mean Raw Score	1980 Mean %	1985 Mean Raw Score	1985 Mean	
Weather	4	1.849	46%	1.624	41%	*
Astronomy	3	1.675	56%	1.625	54%	*
Earth Science	4	2.152	54%	2.330	58%	*
Electricity & Magnetism	4	2.451	61%	2.295	57%	*
Force, Work, Energy	5	2.159	43%	2.078	42%	*
Heat and Temperature	3	1.650	55%	1.439	48%	*
Light	4	2.059	51%	1.767	44%	*
Structure of Matter	4	2.111	53%	2.151	54%	
Physical Properties	3	1.494	50%	1.558	52%	*
Chemical Properties	7	3.113	44%	3.036	43%	
Life Science	15	7.631	51%	7.779	52%	
Nature of Science	5	3.764	75%	3.789	76%	
Processes of Science	3	1.700	57%	1.655	55%	
Safety in Science	4	2.204	55%	2.417	60%	*
Laboratory Techniques	3	1.412	47%	1.413	47%	
TOTAL	71	37.43	53%	36.96	52%	

* indicates statistical significance (p=.05)

These differences in performance between November, 1980, and November, 1985, must be viewed and interpreted with caution. There are many possible factors that could explain these changes. Among these factors are: changes in the prescribed curriculum, changes in teachers' assigned duties, changes in society, changes in the taught curriculum, etc. To separate out possible causal factors would require a study on a much greater scale than the present one. Among factors changing since 1980 it should be noted that although the curriculum for grade 5 and grade 8 students has undergone little change, the grade 10 curriculum has introduced more Life Science and reduced the emphasis on Physical Science laboratory experiences contained in the old I.P.S. program.

TEACHER QUESTIONNAIRE

A Teacher Survey Questionnaire was designed to collect information which would assist in providing a better overview of provincial student performance in science and to provide a better understanding of the conditions relating to the teaching of science in grades 1-6. A total of 577 teachers were sampled, approximately 100 in each grade level. Nine general areas were included.:

I Curriculum Guides,
II Units of study in guides,
III Classroom activities,
IV Evaluation problems,
V Lesson preparation,
VI Facilities,
VII Teaching situation,
VIII Professional development programs,
IX Experience in Science and Science teaching.

Detailed responses to all these items are to be found in the Final Report. The highlights are as follows:

I The Manitoba K-6 Science Curriculum Guide was rated "high" as a major aid in achieving program objectives, as were students' interest and the teachers' attitudes toward teaching science.

II a) Between two-thirds and three-quarters of the teachers rated the "years" sets of teaching units from the guides as appropriate.

b) The factors which rated highest in affecting the teaching of science were: insufficient preparation time, shortages of equipment and/or poor facilities.

III The most frequently occurring classroom activities were: discussing why things happen in nature, communicating the results of an activity or investigation, classifying objects or events, and collecting and

interpreting data from an activity or investigation. The least likely activities were: designing and conducting their own experiments, memorizing science facts and concepts, and working on the computer in science-related activities.

IV The aspects of science which were deemed to be the most difficult to evaluate were: the students' ability to apply the scientific method, the students' laboratory skills, and the processes of science.

V Teachers found the Manitoba K-6 Science Curriculum Guide, and audio-visual materials as being the most important in planning instruction.

VI a) Most teachers teach science in their own classrooms.

b) Most physical facilities available were considered to be inadequate with the plant or animal space and water outlets or sinks as the most inadequate.

VII a) Almost 30% teach in multi-graded classrooms, the highest percentage being at grade 2.

b) Of those teaching in multi-graded classrooms, over half considered it difficult.

c) The major problems of teaching in this sort of classroom were: range of abilities, providing science equipment for the range of grades, having adequate learning materials or textbooks, etc., and being able to accommodate the learning processes for the range of students.

VIII a) Teachers considered these programs as most useful for their professional development: divisional inservices, science programs at SAG, visits to other teachers' classrooms.

b) The following topics were identified by at least 50% of the teachers as useful for future inservice programs: techniques of teaching science, available science resource material, how to prepare science activity kits, science as a way of thinking, organizing for varying abilities, and methods of evaluating science processes.

IX a) Some general experiential background was obtained. About half the teachers have been teaching eleven or more years.

b) From one-quarter to one-third of the teachers had not taken a science course since 1970 or ever. From one-quarter to one-third of the teachers had not taken a science education course since 1970 or ever.

c) Of the college and university science courses taken, the most common were Biology and General Science, and the least common Astronomy and Physics.

CONCLUSIONS

At the risk of oversimplification, a brief overview of the results of the Science Assessment is presented in this section. The reader is strongly urged to read this, the Summary Report, in its entirety. Even more detailed information can be found in the Final Report which received much more limited distribution than the present report.

Grade 3 students generally displayed satisfactory performance on questions dealing with content and processes of science. In their responses to affective items, these students generally displayed an interest in and an enthusiasm for science. Students at this grade level, however, displayed some difficulty in providing complete and precise answers to questions requiring a written response and they had problems with inferring and predicting in the performance component.

Grade 6 students performed adequately on questions utilizing lower-level thinking skills but had more difficulty with questions testing application, analysis, synthesis, and inquiry skills. These students had more difficulty with questions dealing with Science, Society and Technology and with Physical and Earth Sciences than with questions on other topics. Like grade 3 students, they had positive attitudes toward science but also had greater difficulty with questions requiring them to supply their own answers.

Grade 9 students showed evidence of weakness in many of the same areas with which grade 6 students had difficulty. In addition, they had problems with facts and terminology. As at all other grade levels, these students generally had positive attitudes toward science.

The comparison testing showed virtually no change in performance of grade 5 students between November, 1980 and November, 1985. However, grade 8 results indicated a slight decrease on all six topics tested while grade 11 students declined in performance on six topics, showed improvement on three topics, and exhibited no significant change on six topics.

The grades 1 to 6 teacher questionnaire indicates that, among other things, teachers have difficulty evaluating some aspects of science, that most physical facilities are deemed inadequate, that one-third teach science in multi-graded classrooms, that more than one-quarter had not taken a science or science education course since 1970 or had never taken such a course and that few teachers had taken courses in the physical sciences.

RECOMMENDATIONS

The following recommendations are abstracted from Chapter 10 of the 1986 Science Assessment Final Report. All recommendations are made in consideration of the written, performance, comparison and teacher survey components of the 1986 assessment program.

Teachers:

1. That primary teachers place greater instructional emphasis on:

   a) the continued need for safety in the science laboratory and the science classroom,

   b) experiences that involve investigative techniques,

   c) topics in Science, Society, and Technology.

2. That intermediate teachers of Science place greater instructional emphasis on:

   a) the use and understanding of terminology of science,

   b) the higher cognitive levels of thinking, e.g., explanation of physical phenomena,

   c) analysis and interpretation of data,

   d) graphing techniques,

   e) model development as it relates to explanation of physical phenomena,

   f) problem-solving and decision-making,

   g) written and oral experiences relating to science investigations.

   h) laboratory safety.

3. That junior high teachers place greater instructional emphasis on:

   a) frequent, formative assessments to determine student knowledge of the facts and terminology of science content and that where lack of knowledge is indicated, remedial instruction be implemented,

   b) relating the facts and terminology of Science to the larger conceptual schemes and theories embodying them,

   c) the Science, Society, and Technology components and their integration with the remaining curriculum content.

Divisions:

1. That school boards and school administrators ensure that the academic preparation of each science teacher is suitable for his/her respective teaching assignment and that inadequately-prepared teachers not be required to teach science lessons.

2. That provision be made to supply each science classroom with adequate laboratory equipment, supplies and reference materials.

3. That school boards and administrators ensure that all components of the core curriculum in science are implemented, and pupils are evaluated accordingly.

Manitoba Education:

1. That supplementary curricular materials be developed or identified in the following areas:

   a) materials which suggest activities for relating the concepts of Science to the applications of Science, Technology, and Society,

   b) materials providing a number of open-ended activities requiring students to make decisions relative to inquiry investigations and allowing students to implement experiments of their own design,

   c) a series of performance tests to measure the utilization of learning outcomes of the classroom in the context of the laboratory inquiry investigations,

   d) materials for teachers in the use of SI units.

2. That provincial science curricula be revised or modified in the following areas:

   a) greater emphasis to be placed on written and oral communication with respect to scientific inquiry and problem-solving,

   b) greater emphasis on laboratory safety.

3. That professional development be made available in the following areas:

   a) Earth, Space and Physical Sciences topics,
   b) the SI system of measurement,
   c) laboratory safety,
   d) problem-solving, investigative techniques, and treatment of experimental data.

Faculties of Education:

1. That faculties of education ensure that their elementary and secondary degree programs require that each graduate have the necessary course-work and laboratory experience to teach the required science curriculum effectively. In particular, emphasis should be placed on:

   a) problem-solving, investigative techniques, and the treatment of experimental data,
   b) content in the areas of Earth, Space, and Physical Sciences,
   c) laboratory safety.

2. That workshops, short courses and university credit courses be provided for science teachers who need upgrading in content and skill areas and in instructional methodology.